Relationships among swimming performance, body composition and somatotype in competitive collegiate swimmers

WILLIAM A. SIDERS, HENRY C. LUKASKI, WILLIAM W. BOLONCHUK*

*From the USDA, ARS, Grand Forks Human Nutrition Research Center, Grand Forks, ND, USA and the *Department of Health, Physical Education and Recreation, University of North Dakota, Grand Forks, ND, USA*

Reprinted from THE JOURNAL OF SPORTS MEDICINE AND PHYSICAL FITNESS

Vol. 33 - No. 2 - pp. 166-171 (June, 1993)

EDIZIONI MINERVA MEDICA - TORINO

Relationships among swimming performance, body composition and somatotype in competitive collegiate swimmers

WILLIAM A. SIDERS, HENRY C. LUKASKI, WILLIAM W. BOLONCHUK*

*From the USDA, ARS, Grand Forks Human Nutrition Research Center, Grand Forks, ND, USA and the *Department of Health, Physical Education and Recreation, University of North Dakota, Grand Forks, ND, USA*

Relationships were determined between sprint swimming performance and estimates of body composition and somatotype components in competitive collegiate swimmers. Forty-three women and 31 men underwent anthropometric and hydrodensitometric measurements at the beginning of a competitive season. There were significant partial correlations (swim stroke was partialed out) between swimming performance (time in a competitive 100-yard swim of each swimmer's major competitive stroke) and height (-0.466, $p<0.01$), the mesomorphic (0.404, $p<0.01$) and ectomorphic (-0.398, $p<0.01$) components of somatotype, percent body fat (0.351, $p<0.05$), and fat-free weight (-0.332, $p<0.05$) among the women, but no significant correlations among the men. Twenty-three of the women and 21 of the men were also measured and timed at the end of the competitive season. Again, there were significant ($p<0.01$) partial correlations (season and stroke were partialed out) between swimming performance and height (-0.766), fat-free weight (-0.657), body weight (-0.437), and the ectomorphic (-0.441) and mesomorphic (0.392, $p<0.01$) components of somatotype in women, but no significant correlations among the men. These findings indicate that measurements of body composition and somatotype may be predictors of swimming performance in women but not in men.
[J Sports Med Phys Fitness 1993; 33:166-71].

Key words: **Swimming - Body composition - Somatotypes.**

The ideal body composition and the ideal somatotype for participation in a competitive sport varies as a function of the sport or event.[1] Enhanced athletic performance, however, is often associated with decreased body fat.[2] The inference is that enhanced athletic performance is associated with either the lowest body fatness or the highest fat-free weight achievable for a competitor.

When Pugh *et al.*[3] studied swimmers attempting to swim the English Channel, they found that, of those swimmers who were successful, the winners and runners-up tended to have lower percent body fat. Faulkner [4] reported that sprint swimmers were less buoyant, presumably due to less body fat, than distance swimmers. Bloomfield and Sigerseth [5] found no difference in the buoyancy and estimated fatness of university sprint and middle-distance swimmers. It has also been reported [4] that sprint swimmers had a greater mesomorphic component of somatotype than distance swimmers. Stager *et al.*[6] studied a large group of 12-17 year old female swimmers and found that the faster swimmers had greater fat-free weights, but did not differ in body fatness from slower swimmers.

The purpose of this study was to determine body composition and somatotype component correlates of sprint swimming performance in a selected group of competitive, female and male, collegiate swimmers. We include a cross-sectional sample as well as a longitudinal (over a competitive season) sample.

Materials and methods

Forty-three female and 31 male sprint swimmers were recruited from the University of North Dakota varsity teams. Both the women's and the men's teams finished the season by winning their conference meets and 21 of the swimmers (12 women and 9 men) qualified for post-season national competition.

The swimmers underwent anthropometric measurements for the determination of somatotype [7] and body volume measurement (including weight under water) by hydrodensitometry, with simultaneous residual lung volume determination by nitrogen washout, by using the system and method described by Lukaski, Johnson, Bolonchuk and Lykken.[8] Percent body fat was calculated from body density by the formula of Brozek, Grande, Anderson and Keys.[9] The technical error in estimating percent body fat by this method of hydrodensitometry is less than 1%.[10] Fat weight was calculated as percent body fat times body weight; fat-free weight was determined as body weight minus fat weight. Preseason measurements were made during the week before the first practice of the competitive season, and end of the season measurements were made the week prior to the conference meet at the end of the competitive season (12 weeks later).

The index of sprint swimming performance was time in a single competitive 100-yard event of the swimmer's major competitive stroke. Start of the season times were recorded at the first meet of the competitive season and end of the season measurements were recorded at the conference meet at the end of the regular competitive season. Because time in an event was used as an index of performance, decreased time inferred enhanced performance. Thus, variables associated with decreasing or decreased time were, in turn, associated with enhanced performance.

TABLE I.—*Preseason characteristics of 74 sprint swimmers.*

	Female (N=43)	Male (N=31)
Age (years)	19.7±1.4⁺	20.5±1.9
Weight (kg)	63.8±6.7	76.1±5.0*
Height (cm)	168.3±5.8	181.1±5.1*
Weight in water (kg)	1.8±0.6	3.9±0.6*
Body fat (%)	25.0±5.3	14.1±2.9*
Fat weight (kg)	16.1±4.4	10.7±2.3*
Fat-free weight (kg)	47.7±4.7	65.3±4.8*
Endomorphy	3.2±1.0	2.3±0.7*
Mesomorphy	2.9±1.0	3.8±1.0*
Ectomorphy	2.3±1.0	2.8±1.1

⁺Values are mean±SD.
*Mean statistically different from female mean, $p<0.05$.

Two groups of swimmers were identified for assessing the relationships between performance and body composition and somatotype components. A cross-sectional sample of 43 women and 31 men was measured at the beginning of the competitive season; *t*-tests were used to index the differences between the women and men. Partial correlations to remove the effect of different strokes were calculated to determine between-subjects correlations with performance. Twenty-three women and 21 men were still competing in the same event at the end of the season; independent *t*-tests were used to determine the differences between these women and men and dependent *t*-tests were used to determine whether seasonal changes were significant. Partial correlations to remove the effects of season and event were calculated to determine within subjects correlates with swimming performance.

Results

The early season values of body composition and somatotype for the swimmers are presented in Table I. The women and

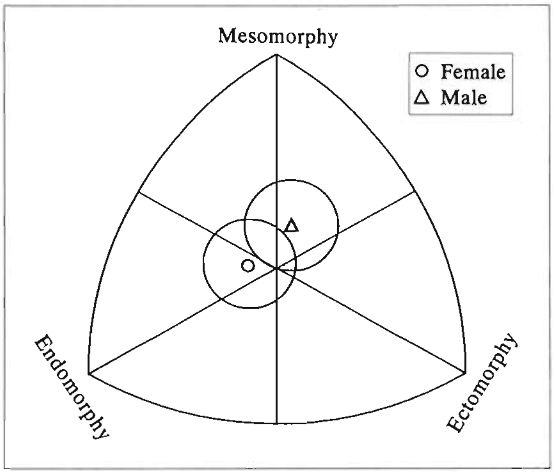

Fig. 1.—Mean Somatotype of Swimmers (43 women and 31 men). The circle about the mean represents the Somatotype Dispersion Index.

TABLE II.—*Early season 100-yard event times (sec).*

	Female (N=43)	Male (N=31)
Backstroke	66.7±4.3, 7[+]	62.4±6.4, 5
Breaststroke	68.8±3.3, 5	68.2±7.4, 8
Butterfly	68.5±5.2, 4	54.4±2.9*, 3
Free style	60.8±4.1, 27	53.4±6.3*, 15

[+]Values are mean±SD, N.
*Mean statistically different from female mean, $p<0.05$.

men differed significantly on every variable except age and the ectomorphic component of somatotype. Figure 1 is a somatochart of the mean somatotypes for each sex.

The swimmers' performance, expressed as race times for the four swimming strokes, is summarized in Table II. The mean times for women and men differed ($p<0.05$) only for the butterfly and free style.

Partial correlations, calculated between the 100-yard event times and the body composition variables and somatotype components, appear in Table III. There were significant ($p<0.05$) negative correlations between time and standing height, the ectomorphic component of somatotype, weight in water, and fat-free weight for women. Also for female swimmers, swim performance was positively correlated with estimates of body fatness and the mesomorphic component of somatotype. No significant relationships were found for male swimmers.

TABLE III.—*Partial correlations between early season 100-yard event times and body composition and somatotype.*

	Female (N=43)	Male (N=31)
Age	−0.186	−0.029
Weight	−0.051	−0.193
Height	−0.466**	−0.009
Weight in water	−0.528**	−0.227
Body fat (%)	0.351*	0.102
Fat weight	0.291	0.050
Fat-free weight	−0.332*	−0.231
Endomorphy	0.239	−0.014
Mesomorphy	0.404**	−0.073
Ectomorphy	−0.398**	0.130

*$p<0.05$.
**$p<0.01$.

Descriptive statistics for the 23 women and 21 men who were measured at the beginning and at the end of a competitive season are in Table IV. The men and women differed significantly on every variable except age and the ectomorphic component of somatotype. During the season, the men experienced a significant increase in standing height (they were still growing) and a significant decrease in percent body fat and fat weight. Fat-free weight increased significantly in women. Figure 2 shows the preseason and end of season mean observed somatotype for female and male swimmers. Figure 2 indicates a preseason to end of season shift in mean somatotype toward increased ectomorphy in both female and male swimmers. The men's and women's mean times for the four strokes are in Table V. The women's times were significantly greater than the men's in all events except the breaststroke. Over the season, the men

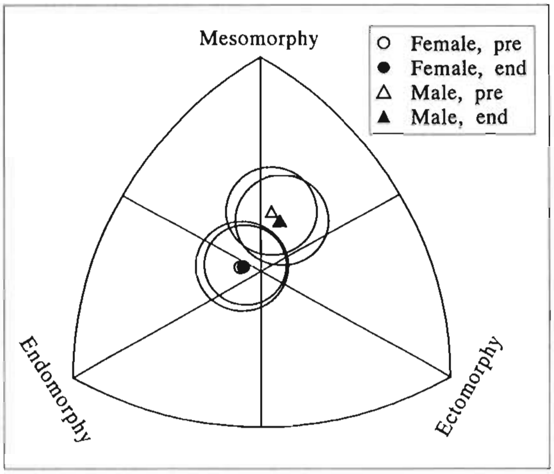

Fig. 2.—Mean Somatotype of Swimmers from preseason to the end of the season. The circle about the mean represents the Somatotype Dispersion Index.

and women significantly improved their times only in the free style event.

Partial correlations, calculated to identify individual correlates among end of season swimming performance and body composition and somatotype components, appear in Table VI. For women, there were significant negative correlations between time and body weight, standing height, the ectomorphic component of somatotype, weight in water, and fat-free weight. There was also a significant positive correlation for women between swim time and the mesomorphic component of somatotype. The positive correlations between swim time and percent body fat and fat weight for men were not significant.

TABLE IV.—*Characteristics of 44 sprint swimmers and changes over a competitive season.*

	Female (N=23)		Male (N=21)	
	Preseason	Change	Preseason	Change
Age	19.9±1.1⁺	—	20.4±1.9	—
Weight (kg)	63.3±5.9	0.2±2.6	77.3±6.2*	−0.8±1.8
Height (cm)	168.5±6.5	0.1±0.7	181.2±5.5*	0.5±0.8**
Weight in water (kg)	1.8±0.5	0.1±0.3	4.0±0.7*	0.1±0.3
Body fat (%)	24.4±3.9	−1.1±2.8	14.6±3.4*	−1.0±1.7**
Fat weight (kg)	15.6±3.6	−0.6±2.0	11.2±2.7*	−0.9±1.4**
Fat-free weight (kg)	47.7±3.7	0.9±2.0**	66.0±6.3*	0.2±1.6
Endomorphy	3.0±0.9	−0.1±0.5	2.2±0.6*	−0.1±0.4
Mesomorphy	2.9±1.1	0.0±0.4	4.1±1.0*	−0.2±0.4
Ectomorphy	2.4±0.9	0.0±0.3	2.6±1.1	0.2±0.3

⁺Values are mean±SD.
*Mean statistically different from female mean, $p<0.05$.
**Preseason mean statistically different from end of season mean, $p<0.05$.
Note: Season changes are end of season values minus preseason values so that a negative change represents a decrease in a variable over a season.

TABLE V.—*Early season 100-yard event times (sec) and changes over a competitive season.*

	Female (N=23)		Male (N=21)	
	Preseason	Change	Preseason	Change
Backstroke	67.8±4.5, 4⁺	−2.2±1.5	61.3±3.8*, 3	−1.4±1.3
Breaststroke	71.8±4.4, 4	−2.7±2.2	69.7±5.7, 2	−2.8±3.6
Butterfly	67.6−0.1, 2	−2.5±1.1	58.4±5.9*, 7	−2.7±3.6
Free style	61.0±5.5, 13	−1.81±2.7**	53.9±6.3*, 9	−2.6±2.5**

⁺Values are mean±SD, N.
*Mean statistically different from female mean, $p<0.05$.
**Preseason mean statistically different from end of season mean, $p<0.05$.

TABLE VI.—*Partial correlations of end of season 100-yard event times with body composition and somatotype.*

	Female (N=23)	Male (N=21)
Age	0.076	−0.026
Weight	−0.437*	0.019
Height	−0.766*	−0.030
Weight in water	−0.460*	−0.077
Body fat (%)	0.198	0.224
Fat weight	0.012	0.221
Fat-free weight	−0.657*	−0.072
Endomorphy	−0.035	0.182
Mesomorphy	0.392*	0.151
Ectomorphy	−0.441*	−0.045

*$p<0.01$.

Discussion

The partial correlations for the cross-sectional group indicated that, among women, better swimming performance (decreased time) in short distance events was related to greater standing height (which was reflected in an increased ectomorphy rating), higher fat-free weight, and lower body fatness. These findings are consistent with the reports of Pugh *et al.*[3] and partially in agreement with the reports of Stager *et al.*[6] Among women, the shared variances ($r^2 \times 100$) for predictors of performance were 21.7% for height, 11.0% for fat-free weight, and 12.3% for percent body fat. The shared variances were relatively low, indicating that other factors (early season fitness and training level, stroke mechanics, etc.) were also important in determining performance.

The positive correlation of performance time with the mesomorphic component of somatotype among women was inconsistent with Faulkner's [4] findings. In this study, the shared variance for mesomorphic component to performance was 16.3%. The selection for increased standing height in a group of meso-endomorphs (their ectomorphy rating was high) did not yield a clearly dominant somatotype among the women and may have confounded the performance and mesomorphy relationship to give a low shared variance.[11]

Over the competitive swimming season, women demonstrated a significant increase in fat-free weight (1 kg), a modest decrease in fat weight (0.6 kg) and a slight increase in body weight (0.2 kg). Within individual women, over a season, improved swimming performance was related to standing height, higher ectomorphic component of somatotype, and increased fat-free weight; the shared variances were, respectively, 58.7%, 19.4% and 43.2%. The observed positive relationship between performance and the mesomorphic component of somatotype among women was also demonstrated among the women with a shared variance of 15.4%.

For collegiate women swimmers, the correlates of body composition with swimming performance were predictable within the general assumptions that fat impedes and fat-free weight enhances sprint swim performance. The negative correlations of improved swimming performance with standing height and the ectomorphic component of somatotype may reflect a leverage, or mechanical, advantage.[4] The shared variances for standing height and fat-free weight are large only in the group of women studied over a competitive season—a group in which fitness levels and skill levels become constant.

The findings of the present study are important because they are independent of some confounding factors inherent in previous studies. The subjects were old enough for natural growth and maturation not to be a major variable. This study included men and women studied longitudinally to examine the influence of a season of training and competition. This study utilized a competitively-derived performance index which minimized the variability in "recalling" one's best performance and standardized the psychological contribution to performance while requiring no disruption of the athletes' training. The results of this study failed to indicate that somatotype components were important correlates of sprint swimming performance in collegiate women and men. Body fat was also not an important correlate with performance. Standing height and fat-free body weight, which are well correlated in the general population,[10] were shown to be important correlates of sprint swimming performance only in women.

References

1. deGaray AL, Levine L, Carter JEL, eds. Genetic and Anthropological Studies of Olympic Athletes. New York: Academic Press, 1974.
2. American Dietetic Association. Nutrition for physical fitness and athletic performance for adults: technical support paper. J Am Dietet Assoc 1987; 87:934-9.
3. Pugh LGCE, Edholm OG, Fox FH *et al.* A physiological study of channel swimming. Clin Sci 1960; 9:257-73.
4. Faulkner JA. Physiology of swimming. Res Quart 1966; 37:41-54.
5. Bloomfield J, Sigerseth P. Anatomical and physiological differences between sprint and middle-distance swimmers at the university level. J Sports Med Phys Fitness 1965; 5:76-81.
6. Stager JM, Cordain L, Becker TJ. Relationship of body composition to swimming performance in female swimmers. J Swim Res 1984; 1:21-6.
7. Carter JEL. The Heath-Carter Somatotype Method. San Diego: San Diego State University, 1975.
8. Lukaski HC, Johnson PE, Bolonchuk WW, Lykken GI. Assessment of fat-free mass using bioelectrical impedance measurements of the human body. Am J Clin Nutr 1985; 41:810-7.
9. Brozek J, Grande F, Anderson JT, Keys A. Densitometric analysis of body composition: revision of some quantitative assumptions. Ann NY Acad Sci 1963; 110:113-40.
10. Lukaski HC. Methods for the assessment of human body composition: traditional and new. Am J Clin Nutr 1987; 46:537-56.
11. Bolonchuk WW, Lukaski HC, Siders WA, Hall CB. The body composition of dominant and modified somatotypes. In: Dotson CO, Humphrey JH, eds. Exercise Physiology: Current and Selected Research, Vol 4. New York: AMS Press, Inc, 1990:145-57.

Address reprint requests to: William A. Siders - USDA, ARS, Grand Forks Human Nutrition Research Center, PO Box 7166, University Station - Grand Forks, ND 58202-7166 (USA).

Tip. S.A.E.M.M. - Saluzzo